THE WEATHER AND CIRCULATION OF JULY 1955 [1]

A Prolonged Heat Wave Effected by a Sharp Reversal in Circulation

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1. INTRODUCTION

Over most of the United States, a generally pleasant and cool June was followed by one of the most prolonged and persistent heat waves ever observed during July. This marked change in temperature was associated with an equally marked reversal in the circulation pattern. The almost complete disappearance of blocking action, which had been so effective in North America and the Atlantic Ocean during June [1], was in large measure responsible for these changes.

[1] See Charts following p. 153 for analyzed climatological data for the month.

2. THE HEAT WAVE

The most newsworthy feature of the month's weather was the heat wave which covered the United States from the Continental Divide to the Atlantic Coast, except for the Gulf States. It was different from most heat waves in several respects: (1) its prolonged and persistent nature, (2) the fact that no absolute maximum temperature records were broken, and (3) the absence of widespread drought conditions.

The hot, humid weather set in rapidly during the last few days of June and became well established by early

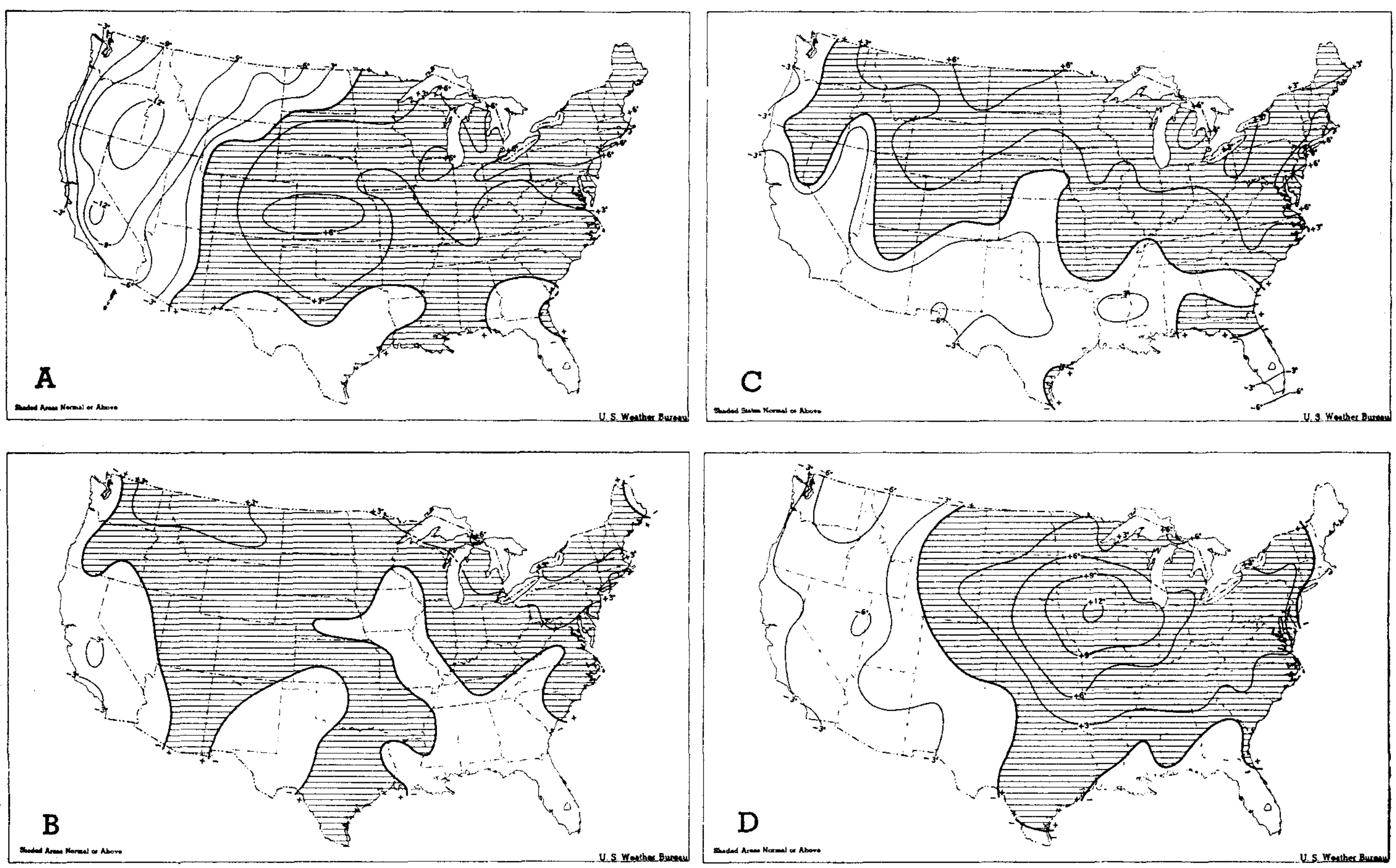

FIGURE 1.—Weekly departure of average temperature from normal, July 1955. (A) July 4–10, (B) July 11–17, (C) July 18–24, (D) July 25–31. Persistence of the temperature pattern is apparent, with below normal temperatures in the Far West and southern portions of the country, and above normal temperatures elsewhere. (From [2].)

July. From then on through the remainder of the month there was little change in the week-to-week temperature pattern [2] (fig. 1). Thus, the patterns shown in Chart I-B and figure 2B were characteristic of the entire month. Temporary relief, however, was afforded residents of the Midwest near the middle of the month when a somewhat cooler air mass pushed in from the Pacific (fig. 1B). The hottest weather occurred during the last week and was centered in Iowa where temperatures as much as 12° F. above normal were observed for the 7-day period (fig. 1D). Des Moines, Iowa reported maximum temperatures of 100° F. or more on the last 5 days of the month with a high of 105° F. on the 31st. Omaha, Nebr. also had its hottest day of the month at the same time with 108° F. A change to cooler weather in the Northeast, during the last week, brought to most of New England its only period of below normal temperatures for the month (fig. 1D).

Surprisingly enough, no absolute maximum temperature records for July were broken, although many large cities reported their highest July monthly mean temperature of record. These included Chicago, Ill., Cleveland, Ohio, Detroit, Mich., Hartford, Conn., New York, N. Y., Philadelphia, Pa., Baltimore, Md., and Washington, D. C. Another measure of persistence of the heat is the large number of cities where the number of days with temperature 90° F. or above broke or tied July records. These included, in addition to most of those listed above, Minneapolis, Minn., Lansing, Mich., Indianapolis, Ind., Albany, N. Y., and Boston, Mass. Furthermore, several cities in Indiana and Kentucky did not report a single day on which the temperature was below normal. Statewide temperature averages showed that New Jersey experienced its hottest July since 1887.

TABLE 1.—*Number of Julys in the period 1893–1952 when United States mean temperature, weighted according to State area, was above or below the normal of 74.3° F. Julys with exactly normal means are omitted*

	1893–1912	1913–1932	1933–1952
Above normal	6	10	14
Below normal	13	10	5

To some extent the recent heat wave represents a continuation of a long-period climatic warming. Table 1 shows the number of Julys when the mean temperature for the United States (weighted according to the area of each State) was above or below normal during the three 20-year periods from 1893 to 1952. Those Julys with exactly normal values (74.3° F., based on 62 years of record) are omitted from the table. If we include July 1953, 1954, and 1955 in the last column, it then becomes: Above normal 16 and Below normal 5. Thus, there appears to have been a definite warming trend during July.

A glance at figure 2 shows how marked the temperature reversal was from June to July. Namias [3] found that, on the average, there is about 70 percent persistence (0 or 1 class change) in the temperature pattern from June to July. This year there was only 41 percent persistence. Moreover, 15 percent of reporting stations observed the extreme change from much below to much above normal temperature.

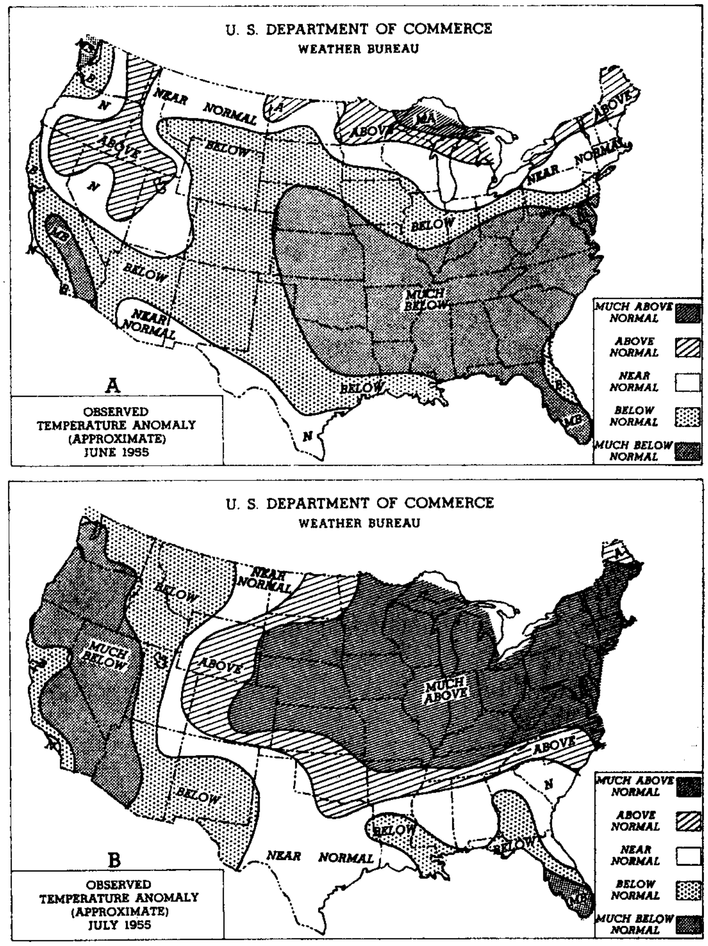

FIGURE 2.—Monthly mean surface temperature anomalies for (A) June 1955 and (B) July 1955. The classes above, below, and near normal occur on the average one-fourth of the time; while much above and much below each normally occur one-eighth of the time. Note the marked reversal in pattern from the Rocky Mountains eastward.

3. THE HEAT WAVE RELATED TO THE MEAN CIRCULATION

As is usually the case, such rapid changes in the temperature pattern were produced by marked changes in circulation. In the June article of this series, Hawkins [1] described the effect of blocking action in North America upon the weather and circulation in the United States. At that time the main westerly jet stream was located far south of its normal position in the eastern United States (fig. 3A), and wind speeds were nearly 7 m./sec. below normal over the Great Lakes. A vast area of subnormal wind speeds extended from the central Rockies eastward to the Atlantic Coast and northward to Newfoundland

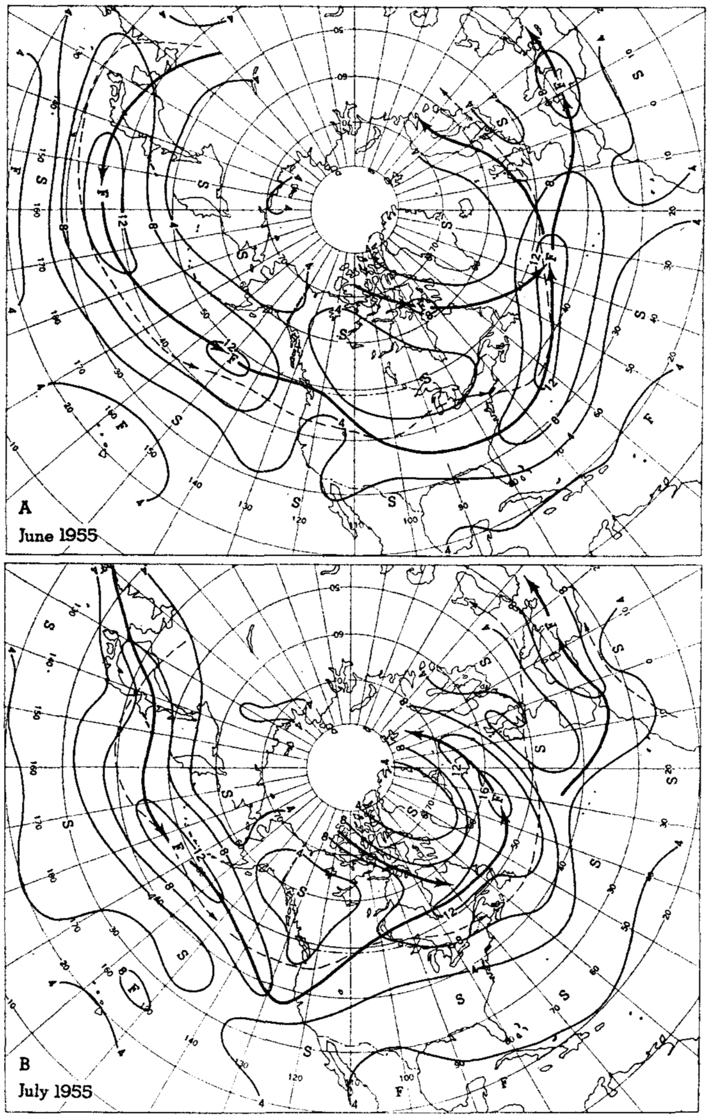

FIGURE 3.—Mean 700-mb. wind speeds (isotachs drawn at intervals of 4 meters/sec.) for (A) May 31–June 29, 1955 and (B) July 2–31, 1955. Solid arrows indicate the average position of the principal jet stream at this level. Dashed arrows give the normal position of the jet stream for each month. "F" refers to areas of fast wind speeds; "S", to areas of light winds. Far northward position of the westerlies in eastern North America in July was a marked change from June.

and Hudson Bay. The monthly mean 700-mb. High cell was over northeastern Mexico.

The change that followed in July is indicated by comparing the average monthly positions of the jet streams in figure 3. Notice (fig. 3B) that in eastern North America the main westerly jet was displaced far north of both its June and its normal July positions. The monthly mean 700-mb. High cell over the Tennessee Valley in July appears to be traceable from its June position over Mexico to the Louisiana coast from mid-June to mid-July (fig. 4). In the southern United States, where the westerly jet was strongest in June, July had a zone of relative calm associated with the extensive upper-level High. From Hudson Bay eastward to the Atlantic Coast, July wind speeds were 5 to 6 m./sec. above the normal with observed speeds of 12 m./sec. The contrast between June and July is further highlighted by comparing their 700-mb. zonal wind speed profiles (Western Hemisphere) (fig. 5). The latitude of maximum west wind speed (jet) moved north about 10° from 42° N. in June to 52° N. in July.

The general northward displacement of the belt of maximum winds (figs. 3 and 5) resulted in a subnormal value of the monthly mean zonal index at 700 mb. for the Western Hemisphere (35° N.–55° N.). A value of 6.6 m./sec. ties with that of July 1952 for the lowest of record (since 1943). At the same time the index of polar westerlies (55° N.–70° N.) at 700 mb. was 4.4 m./sec., the highest of record (since 1945). In this connection it is interesting to note that the lowest polar westerlies index ever observed, 0.6 m./sec. in July 1950, was accompanied by subnormal temperatures over nearly the entire country. Thus, in July high values of the polar westerlies and low values of the zonal westerlies have been associated with mainly above normal temperatures in the United States, and low polar westerlies and high zonal westerlies with subnormal temperatures, a long-suspected general relationship. To check this statistically, simple linear correlation coefficients were computed relating the mean United States weighted temperature averages for all Julys for the period 1945–1954, with both the corresponding polar westerly and zonal westerly indices. The correlation between temperature and polar westerlies was +0.59, and that between temperature and zonal westerlies −0.57. These coefficients would undoubtedly have been higher if July 1955 could have been included, but the mean temperature for the United States was not yet available. The shortness of the period of record does not allow any strong inferences to be made regarding these correlations.

Establishment of the vast, warm anticyclonic cell in the eastern United States early in the month exerted a basic control upon the weather over nearly the entire country, with the exception of the Far West. This cell extended vertically to the upper reaches of the troposphere (Chart XV), and was intimately related to the heat wave previously discussed.

Changes that evolved in the general circulation were related to the growth of this high pressure cell. During June the eastern Pacific semi-permanent anticyclone was located about 12° of longitude northeast of its position on the normal map [4]; the ridge associated with this cell had heights of 260 ft. above the normal. Continued building and northward motion of this cell occurred in July and heights remained considerably above the normal.

At the same time, blocking action, centered over Hudson Bay in June, began to relax over North America and to spread its effects into Alaska and northwestern Canada. In July this blocking surge was somewhat weaker than in June and was associated with an anomaly of +80 ft. centered in the northern Yukon. It is conceivable that this block also had some effect in helping to

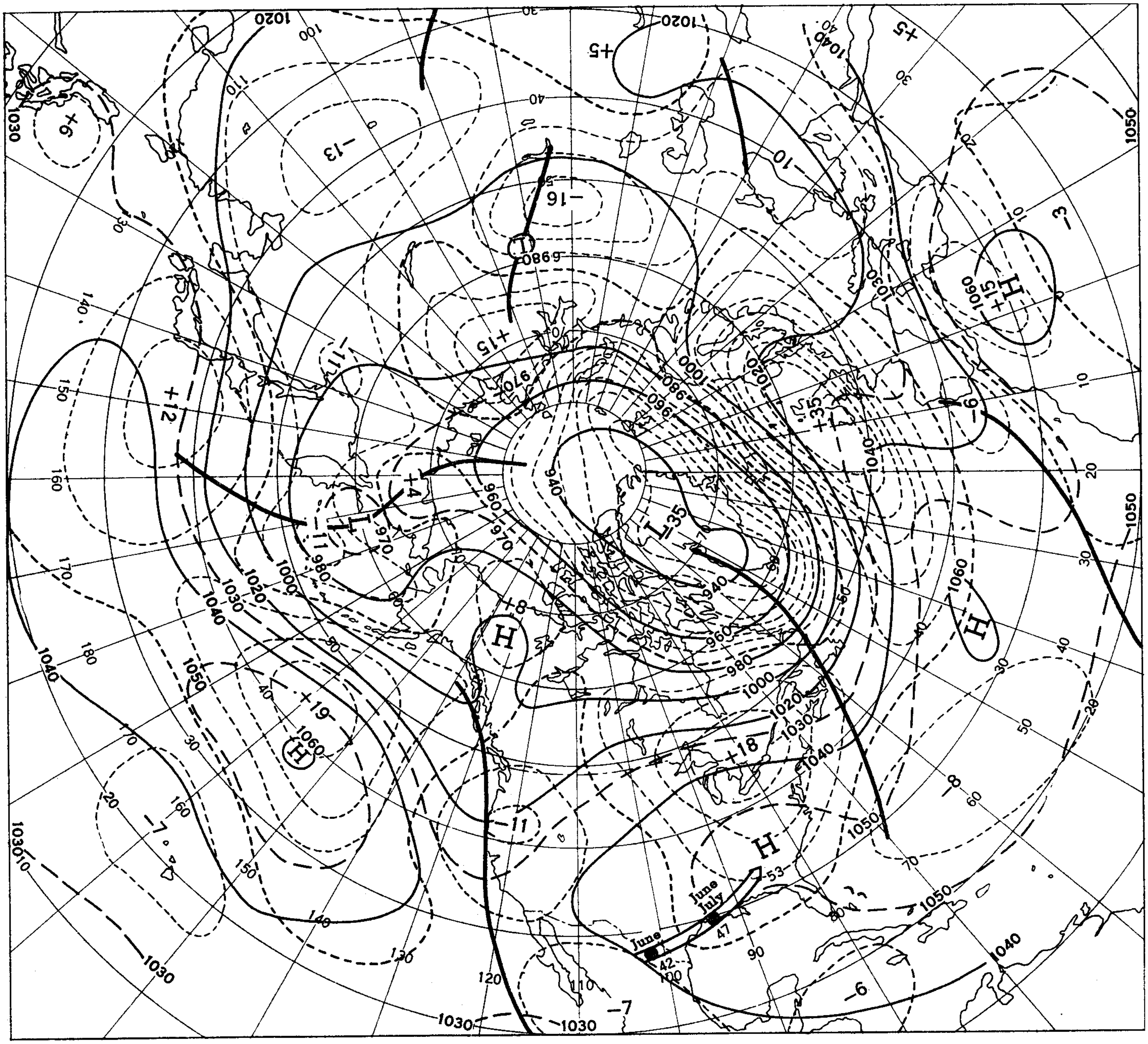

FIGURE 4.—Mean 700-mb. contours and height departures from normal (both in tens of feet) for July 2–31, 1955. Strong anticyclogenesis in the eastern half of the United States represented a major change from June (note track and intensification of High cell). Abnormally strong westerlies characterized the circulation in the Pacific, eastern Canada, and the Atlantic. Blocking was a feature in Europe and Asia.

build the eastern Pacific ridge. Note the zone of positive anomaly extending from the Yukon through the Gulf of Alaska to the +190-ft. center in the eastern Pacific (fig. 4). The building of this ridge, combined with a relaxation of blocking in most of North America, led to major changes in the circulation pattern downstream.

In June the major trough-ridge systems in the Western Hemisphere were relatively weak and had little amplitude. The 700-mb. pattern for July in the same area shows deeper-than-normal troughs and stronger-than-normal ridges, and, in general, much greater amplitude. Strengthened northwesterly flow off the Pacific Coast, and its associated transfer of momentum downstream, resulted in a deep trough near its normal position on the Pacific Coast. At the same time an upper-level ridge began to build sharply into the eastern United States. Its location over the Great Lakes represents a displacement of about 20° east of its normal position [4]. One way of portraying the magnitude of the changes just discussed is to compute the change of monthly mean 700-mb. height anomaly from June to July (fig. 6). Note in particular the areas of strong positive anomalous change in Alaska and the

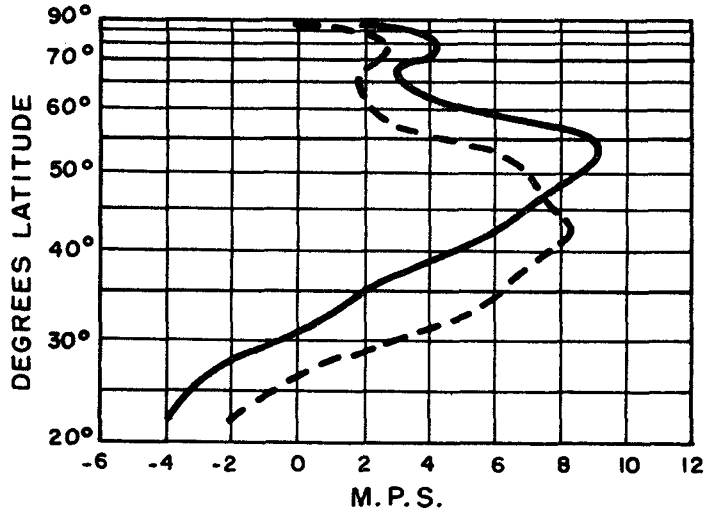

FIGURE 5.—Mean 700-mb. zonal wind speed profile in the Western Hemisphere for June 1955 (dashed line) and July 1955 (solid line). The normal July profile (not shown) is approximately half way between the two curves. Note the sharpness of the July west wind maximum and its increase and northward displacement from the June value.

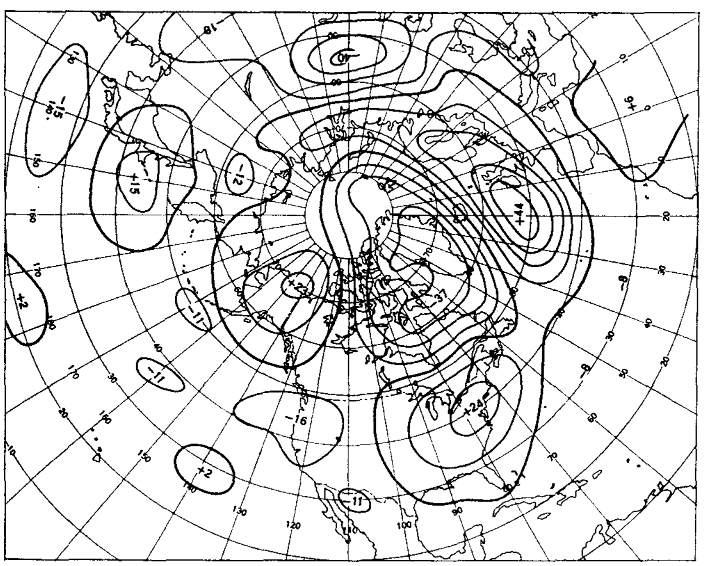

FIGURE 6.—Change in mean 700-mb. height departure from normal from June to July 1955. The lines of equal anomalous height change are drawn at 50-ft. intervals with the centers labeled in tens of feet. The sharp changes from North America eastward to central Asia are most striking.

Middle Atlantic States, also the negative area in the Pacific States. Increased anomalous southerly flow over the central United States was conducive to the deployment of warm, moist tropical air masses into the country.

Summing up then, we can say that the heat wave in the eastern two-thirds of the United States was accompanied by strong anticyclogenesis resulting largely from: (1) transfer of momentum downstream, (2) relaxation of blocking in North America, and (3) the rapid shift northward of the jet stream (in part, a normal climatological feature).

The circulation pattern of July 1955 was quite typical of heat wave situations in the Midwest and eastern United States. In 1952 Klein [5] prepared a composite 700-mb. chart based on the 10 hottest 5-day mean periods at Kansas City during the summer months from 1947 to 1951. This chart (not shown here) bears a close resemblance to the observed map for July 1955. Features common to both maps are: stronger-than-normal ridges near 150° W. in the Pacific and over the Great Lakes, a stronger-than-normal trough along the west coast, a weak trough off the east coast, and a confluence zone in southeastern Canada. The persistent southwesterly flow thus created, from the Rocky Mountains to the Great Lakes, effectively prevents the intrusion of cooler Canadian air masses into the country.

4. OTHER ASPECTS OF THE WEATHER IN THE UNITED STATES

While the eastern two-thirds of the country sweltered, the region west of the Continental Divide continued its pattern of below normal temperatures. Cool weather in the West has prevailed, almost without exception, since December 1954. In the interior valleys of California and in portions of northern Nevada, temperatures were as much as 6° F. below normal. Fresno, Calif. had its coldest July of record; also, its 14th consecutive month of subnormal temperatures. The coolest weather occurred early in the month when temperatures of 12° F. below the normal were reported (fig. 1A). Winnemucca, Nev. recorded a minimum temperature of 29° F. on the 5th, the lowest ever observed there in July. These subnormal temperatures were caused by frequent intrusions of cool Pacific air masses into a deeper-than-normal 700-mb. trough (fig. 4). At sea level, no closed High centers were tracked inland (Chart IX) with these air masses, which were associated only with protrusions of the semi-permanent Pacific High (Chart XI). Subnormal temperatures also prevailed quite generally in the Southern States from the Rockies to the Atlantic Coast. These cool conditions were caused by the prevalence of cloudiness and showers in moist tropical air and were related to anomalous easterly flow components (fig. 4).

Precipitation during July was fairly well distributed over the country and was generally heavier than in June. The deep trough along the Pacific Coast resulted in greater-than-normal rainfall over nearly all regions west of the Continental Divide (Charts II and III–B). An exception was central and southern California where normally no rain falls during the summer. Strong convergence in the mean trough effected a release of moisture both in Pacific air masses and in the southwestern moist tongue.

Rainfall was also above normal from the northern Rockies to Wisconsin, where surface fronts were present 70 percent of the time (fig. 7). It was in this region that the main cyclonic activity in the United States developed

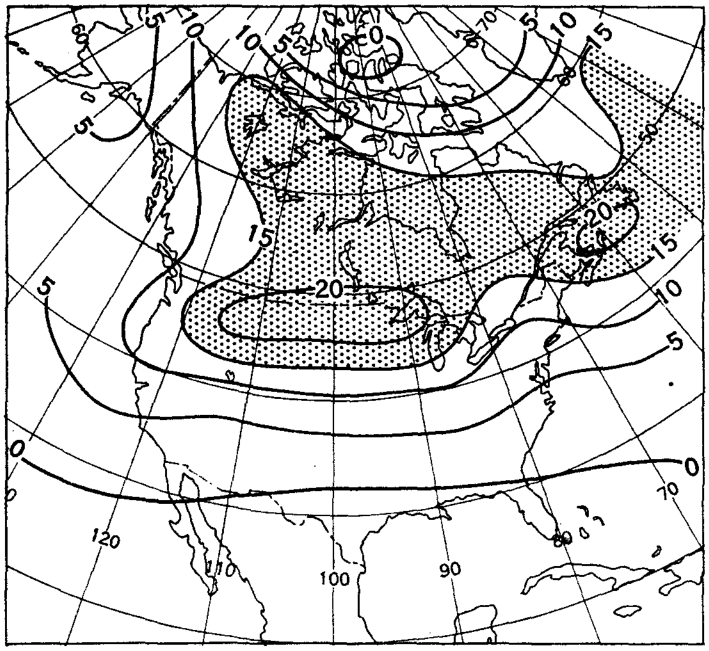

FIGURE 7.—Number of days in July with surface fronts of any type (within squares with sides of approximately 500 miles). Frontal positions taken from *Daily Weather Map*, 1:30 p. m., EST. The high frequency of fronts from Wisconsin to the Pacific Coast was related to the heavier-than-normal precipitation in that region.

(Chart X). This activity, in the form of rather weak frontal waves, fed on the strong thermal contrast (fig. 2B and Chart I–B) and was steered northeastward by the upper-level flow. Also related to heavier-than-normal precipitation in this area were the stronger-than-normal anomalous southerly flow components in the monthly mean 700-mb. circulation (fig. 4). Over most of Minnesota and northwest Wisconsin more than twice the normal amount of rain fell (Chart III–B). The combination of high temperatures and heavy precipitation here was rather unusual in view of the negative correlation that exists between these two elements in summer. Early in the month numerous hailstorms occurred in the northern Great Plains and the upper Mississippi Valley. Several tornadoes were reported in Minnesota.

Widespread and generally heavy precipitation also fell in the Gulf States and Florida. Rainy, cloudy weather here was the result of frequent easterly wave activity to the south of the upper-level High center. The season's second tropical storm (Brenda) developed in the Gulf of Mexico at the end of the month and moved into Louisiana on August 1, accompanied by heavy rains. This storm, however, never attained hurricane force.

Precipitation was generally deficient in the central and southern Great Plains (Charts II and III–B). The explanation for this is not too clear, in view of the anomalous southerly flow (although weak) in this area. Factors involved were probably: (1) the northward shift of the axis of the mid-tropospheric High at 700-mb. from its normal position, near latitude 27° N. in the eastern Gulf of Mexico, to latitude 35° N.; and (2) a westward shift of the southwestern moist tongue. Subnormal amounts of rainfall were also observed in the Great Lakes region and in the Northeast. There was abundant sunshine (Chart VII), associated with anticyclonic curvature and northwesterly flow aloft, in these areas where only one cyclone, and that a rather weak system, passed during the month (Chart X). New York State reported its second driest July on record, while Pennsylvania and New Jersey also approached records for dryness. The Tennessee Valley, directly beneath the Continental anticyclone, also had a deficiency of precipitation.

5. CIRCULATION AND WEATHER HIGHLIGHTS ELSEWHERE

When blocking reached its peak in Alaska—July 20 to 27—and 700-mb. heights were 400 ft. above the normal, the residents of Alaska had a heat wave of their own. The temperature reached 93° F. in Fairbanks and 80° F. in the Eskimo village of Wainwright on the Arctic Coast. The heat brought with it the rare phenomena of lightning and thunder to the Arctic regions.

In Ontario, Canada, the combination of high temperatures and subnormal rainfall, associated with the persistent upper-level ridge (fig. 4), brought a rash of forest fires to the sun-baked woodlands. The situation was described as the worst in the Province's history.

The retrogression of the Canadian block to Alaska helped to develop a deep trough in the Davis Strait, where an anomaly of −350 ft. was observed (fig. 4). Strong northwesterly flow to the rear of this trough and southwesterly flow in western United States combined to produce the strong confluence zone in southeastern Canada. The jet of maximum winds emanating from this zone, was accompanied by wind speeds of 16 m./sec. in the North Atlantic (fig. 3B)—some 11 m./sec. above the normal for July. North of the jet, cyclonic activity was extremely frequent, in both central Canada and the North Atlantic (Chart X).

Blocking operated very strongly in Europe and Asia. Notice (fig. 4) the strong height anomaly of +350 ft. over Great Britain and the zonal band of positive anomaly extending eastward to the +150-ft. center in Northern Asia. South of this positive anomaly zone was an extensive band of negative anomaly stretching from Portugal eastward to China. A split jet, a warm High, and a closed low-latitude Low, all characteristics of blocking, were observed during the month. In Europe the block occurred in two major surges, one in each half of the month. The first, and strongest, brought with it an 8-day heat wave in Western Europe and Scandinavia, with temperatures of 91° F. reported in Norway. Persistent anticyclonic conditions over the British Isles resulted in the sunniest and driest July on record in many districts, while a maximum temperature of 88° F. was observed in the London area on the 18th.

Additional weather highlights included several typhoons in the South Pacific and a reported temperature of 122° F. in Ghardimaou, a village in northern Tunisia.

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2. U. S. Weather Bureau, *Weekly Weather and Crop Bulletin, National Summary*, vol. XLII, Nos. 28, 29, 30, 31, July 11, 18, 25, and August 1, 1955.
3. J. Namias, "The Annual Course of Month-to-Month Persistence in Climatic Anomalies," *Bulletin of the American Meteorological Society*, vol. 33, No. 7, Sept. 1952, pp. 279–285.
4. U. S. Weather Bureau, "Normal Weather Charts for the Northern Hemisphere," *Technical Paper* No. 21, Washington, D. C., 1952, 74 pp.
5. W. H. Klein, "The Weather and Circulation of June 1952—A Month with a Record Heat Wave," *Monthly Weather Review*, vol. 80, No. 6, June 1952, pp. 99–104.

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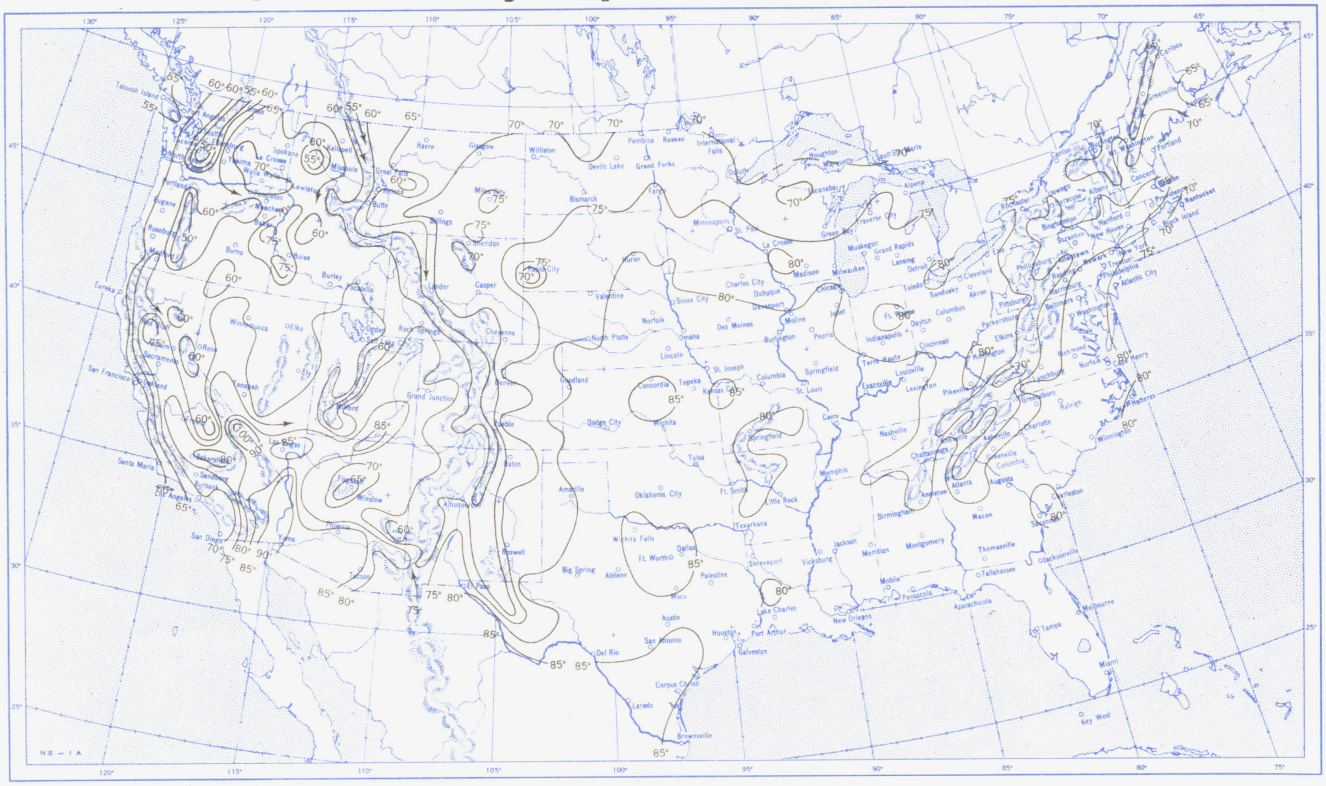
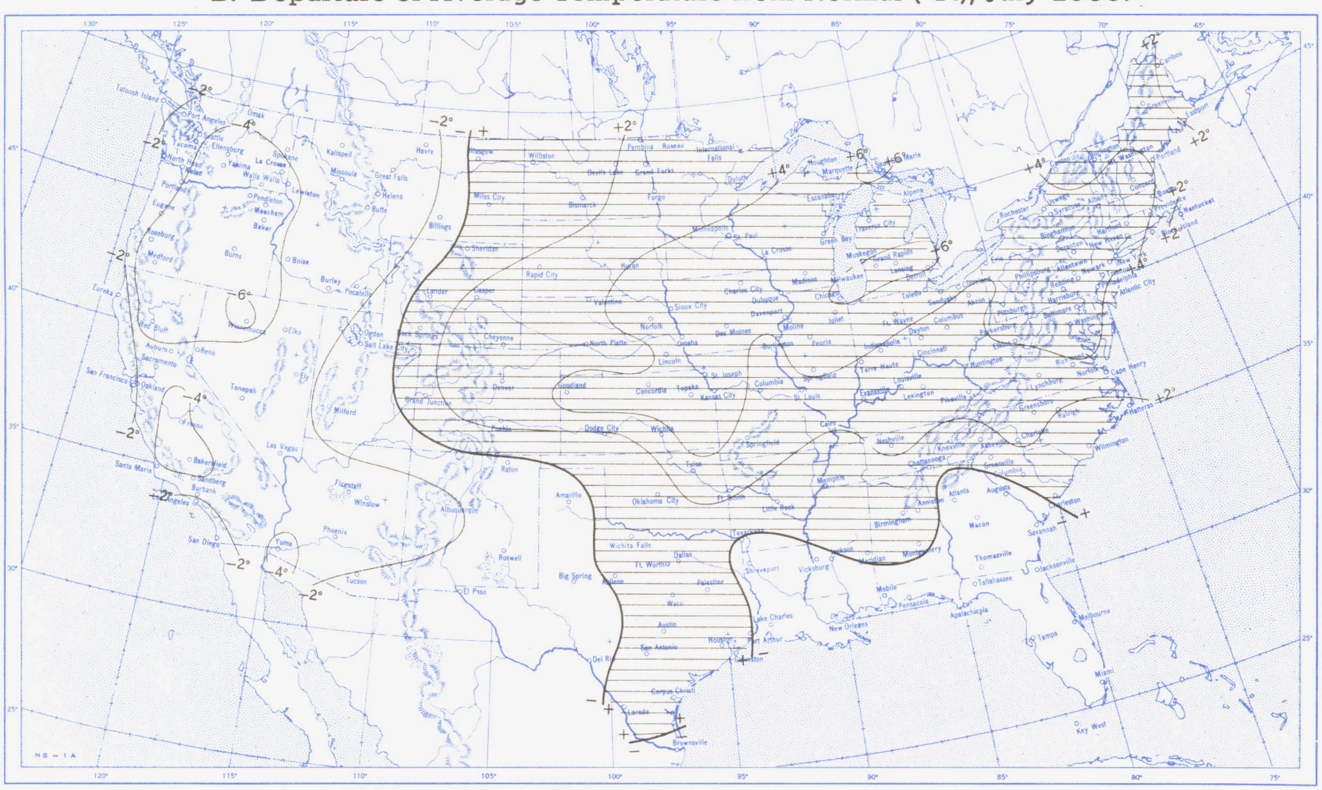
Chart I. A. Average Temperature (°F.) at Surface, July 1955.



B. Departure of Average Temperature from Normal (°F.), July 1955.



A. Based on reports from 800 Weather Bureau and cooperative stations. The monthly average is half the sum of the monthly average maximum and monthly average minimum, which are the average of the daily maxima and daily minima, respectively.

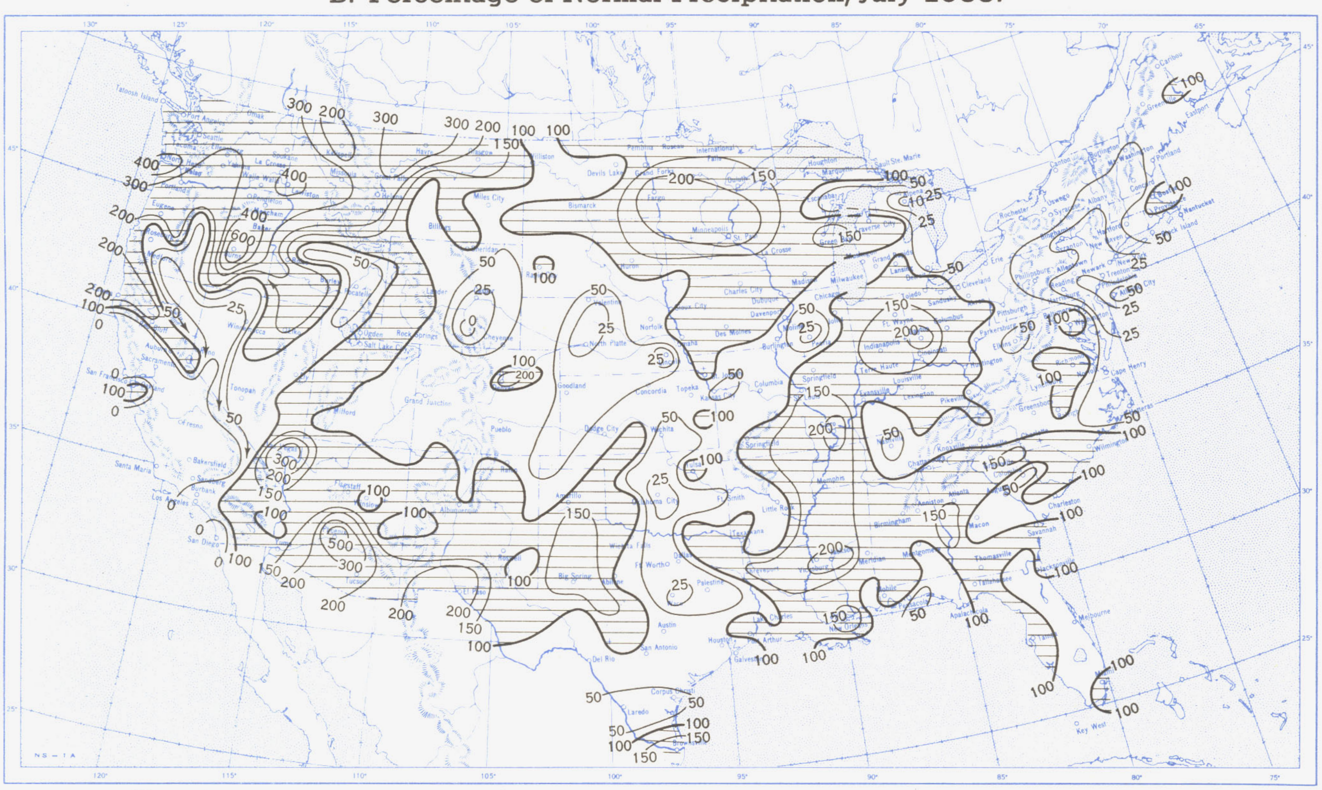
B. Normal average monthly temperatures are computed for Weather Bureau stations having at least 10 years of record.

Chart II. Total Precipitation (Inches), July 1955.

Based on daily precipitation records at 800 Weather Bureau and cooperative stations.

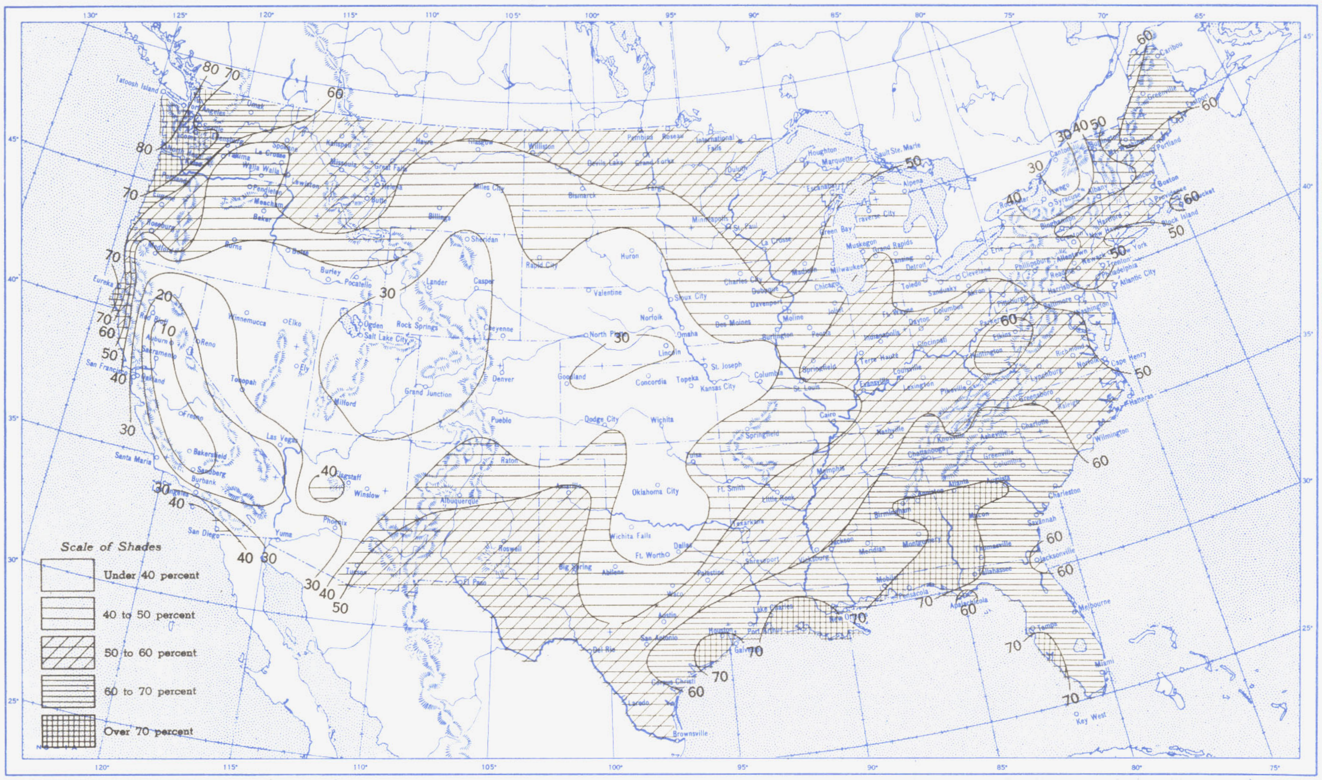
Chart III. A. Departure of Precipitation from Normal (Inches), July 1955.

B. Percentage of Normal Precipitation, July 1955.

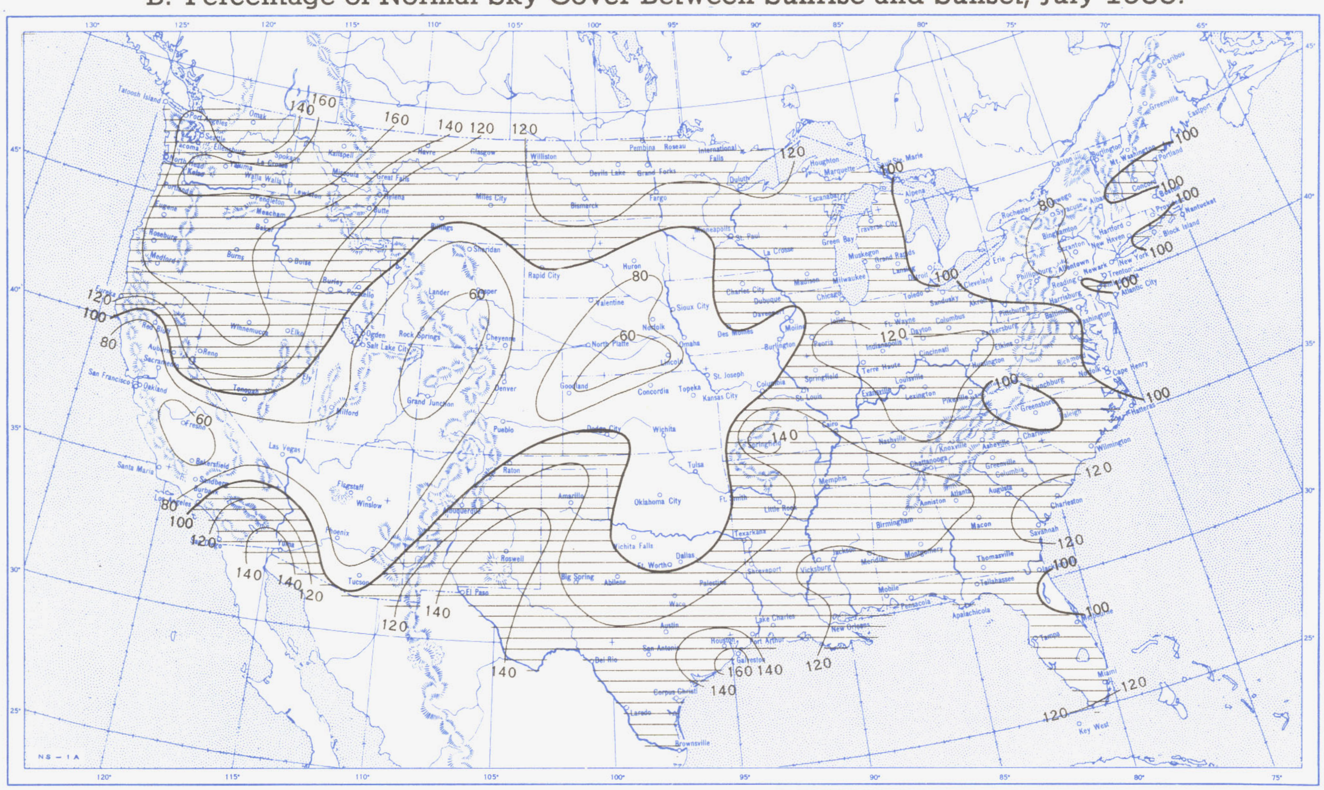


Normal monthly precipitation amounts are computed for stations having at least 10 years of record.

Chart VI. A. Percentage of Sky Cover Between Sunrise and Sunset, July 1955.

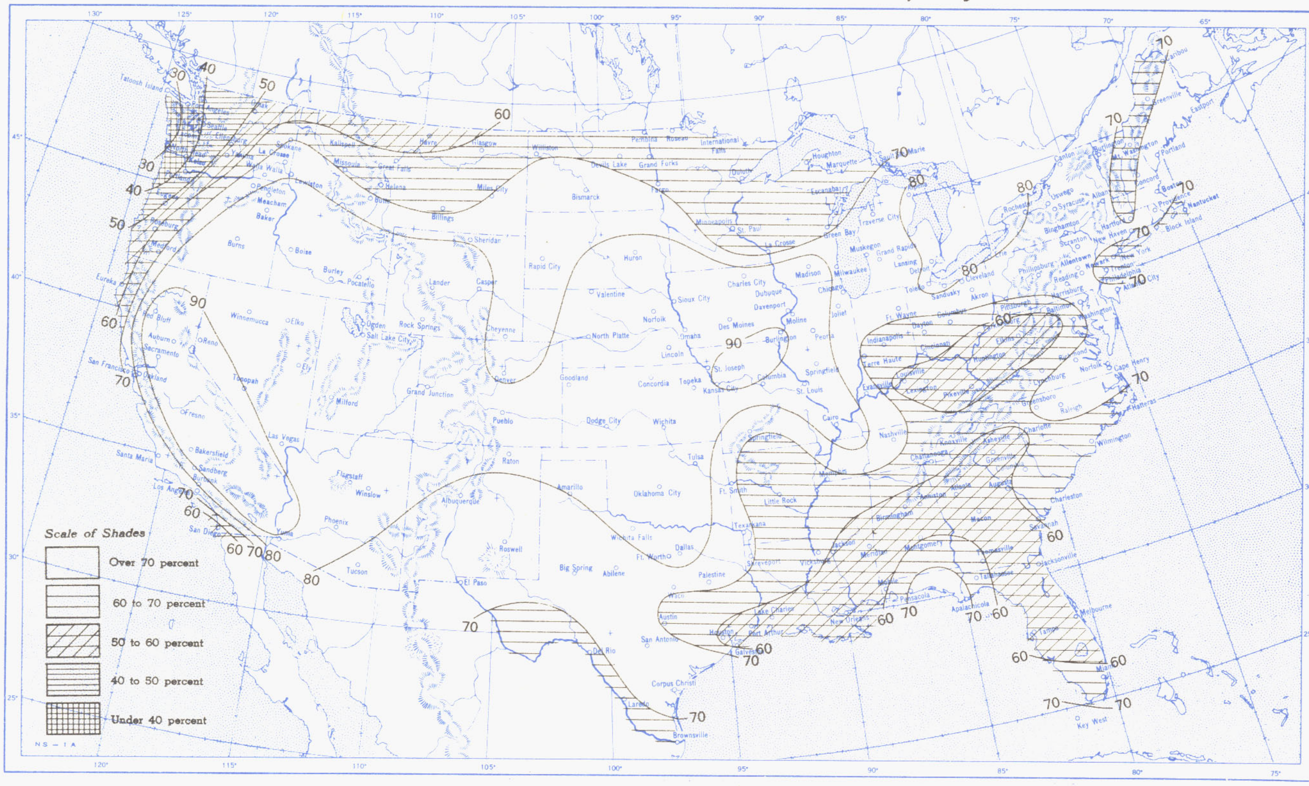


B. Percentage of Normal Sky Cover Between Sunrise and Sunset, July 1955.

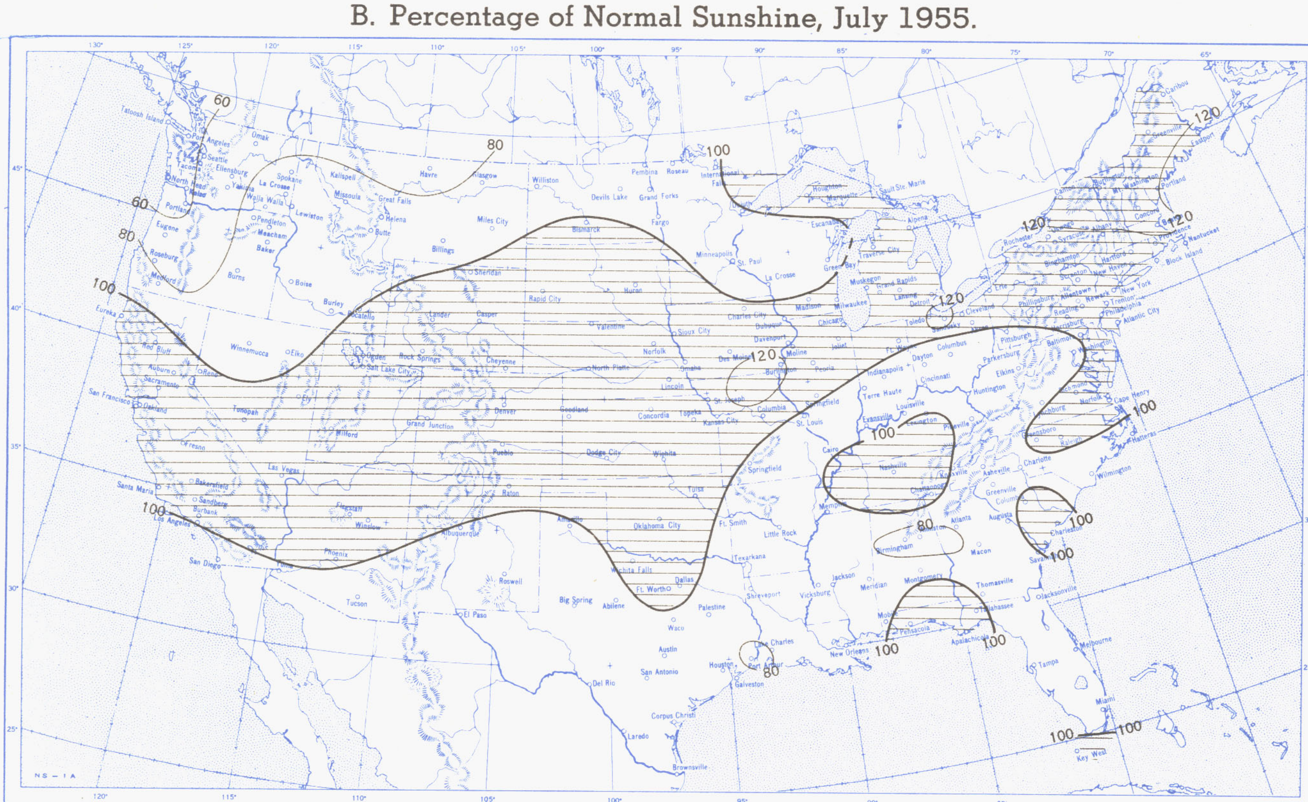


A. In addition to cloudiness, sky cover includes obscuration of the sky by fog, smoke, snow, etc. Chart based on visual observations made hourly at Weather Bureau stations and averaged over the month. B. Computations of normal amount of sky cover are made for stations having at least 10 years of record.

Chart VII. A. Percentage of Possible Sunshine, July 1955.



B. Percentage of Normal Sunshine, July 1955.



A. Computed from total number of hours of observed sunshine in relation to total number of possible hours of sunshine during month. B. Normals are computed for stations having at least 10 years of record.

Chart VIII. Average Daily Values of Solar Radiation, Direct + Diffuse, July 1955. Inset: Percentage of Normal Average Daily Solar Radiation.

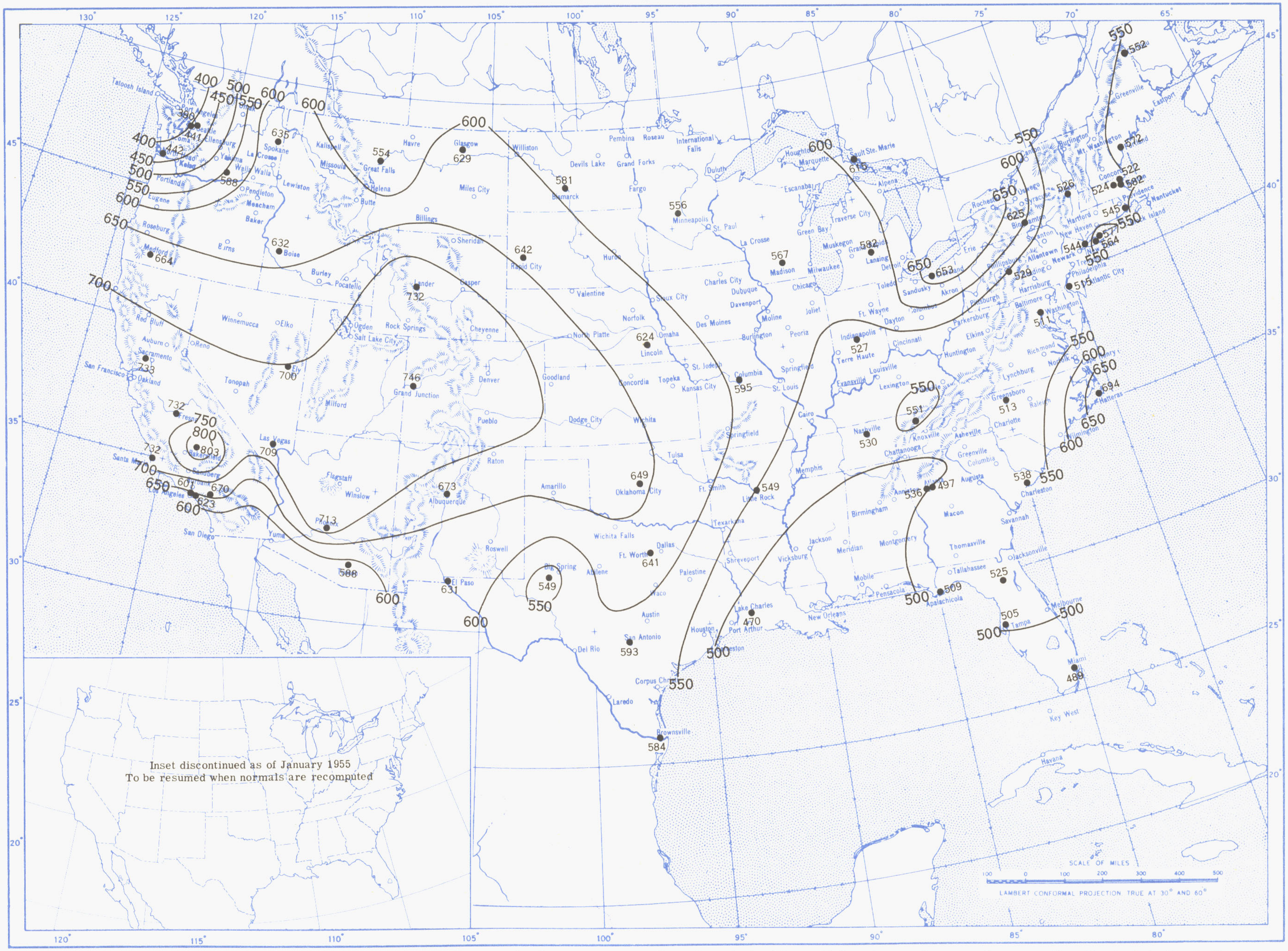
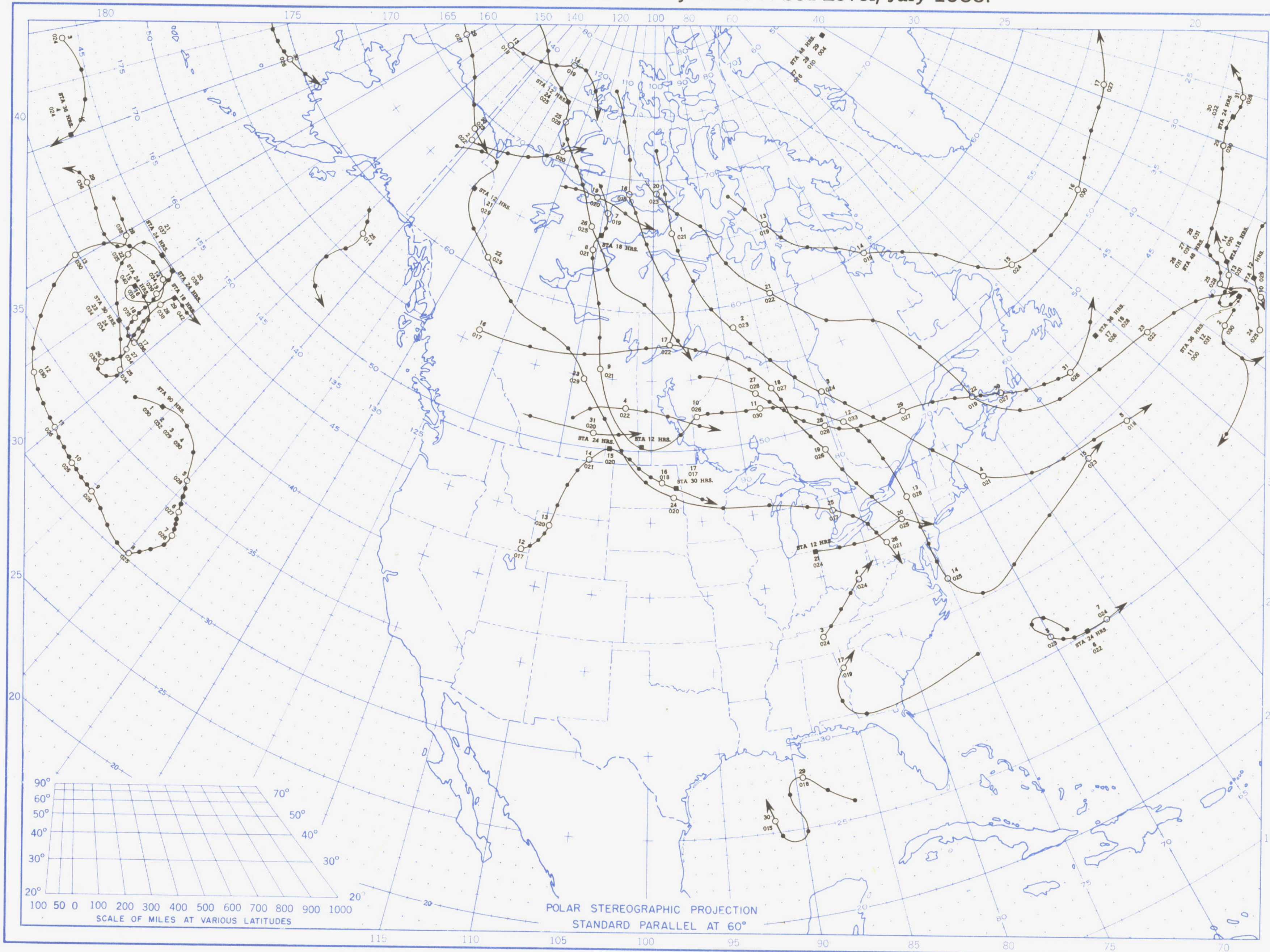


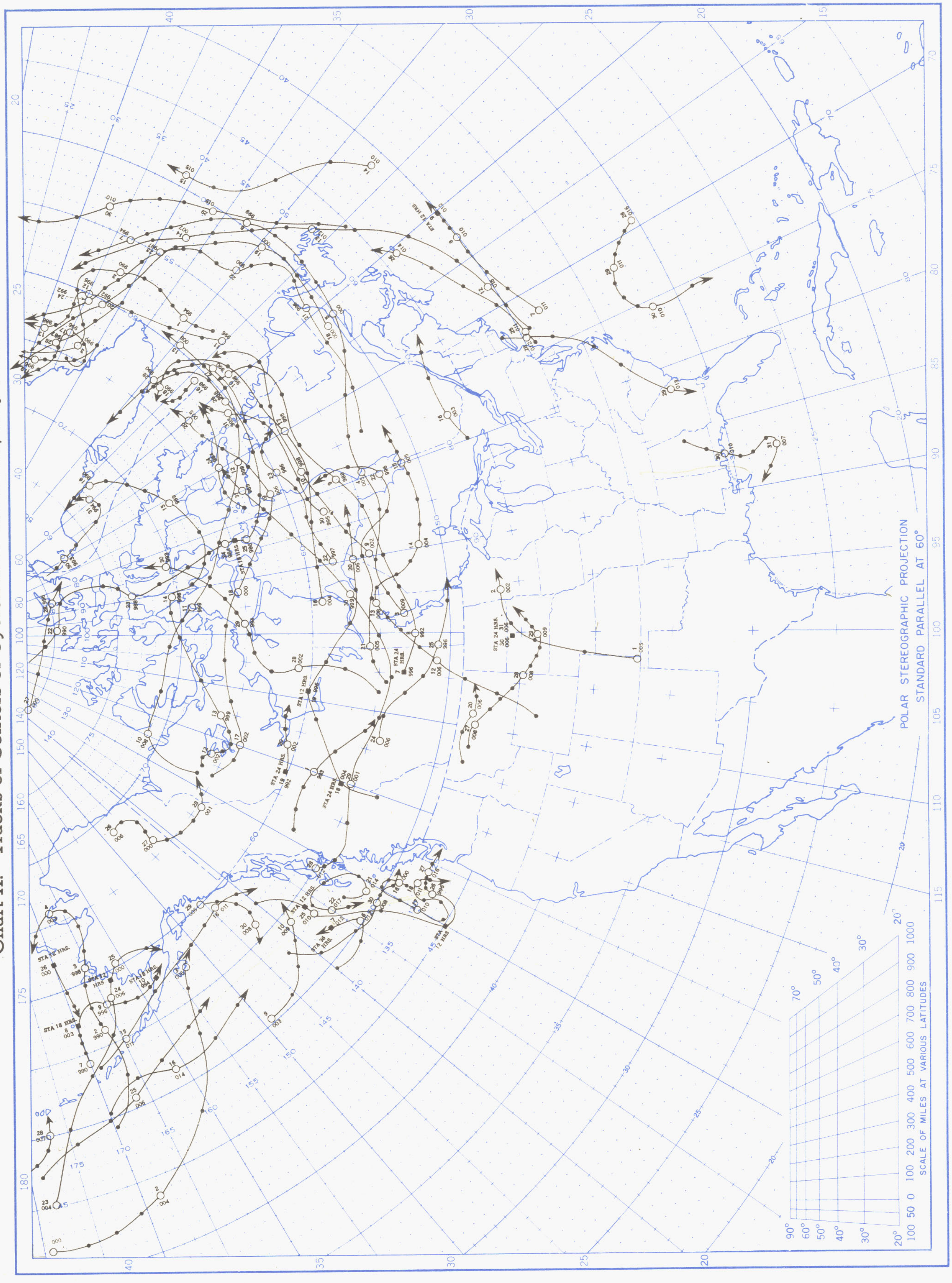
Chart shows mean daily solar radiation, direct + diffuse, received on a horizontal surface in langleys (1 langley = 1 gm. cal. cm. $^{-2}$). Basic data for isolines are shown on chart. Further estimates are obtained from supplementary data for which limits of accuracy are wider than for those data shown.

Chart IX. Tracks of Centers of Anticyclones at Sea Level, July 1955.



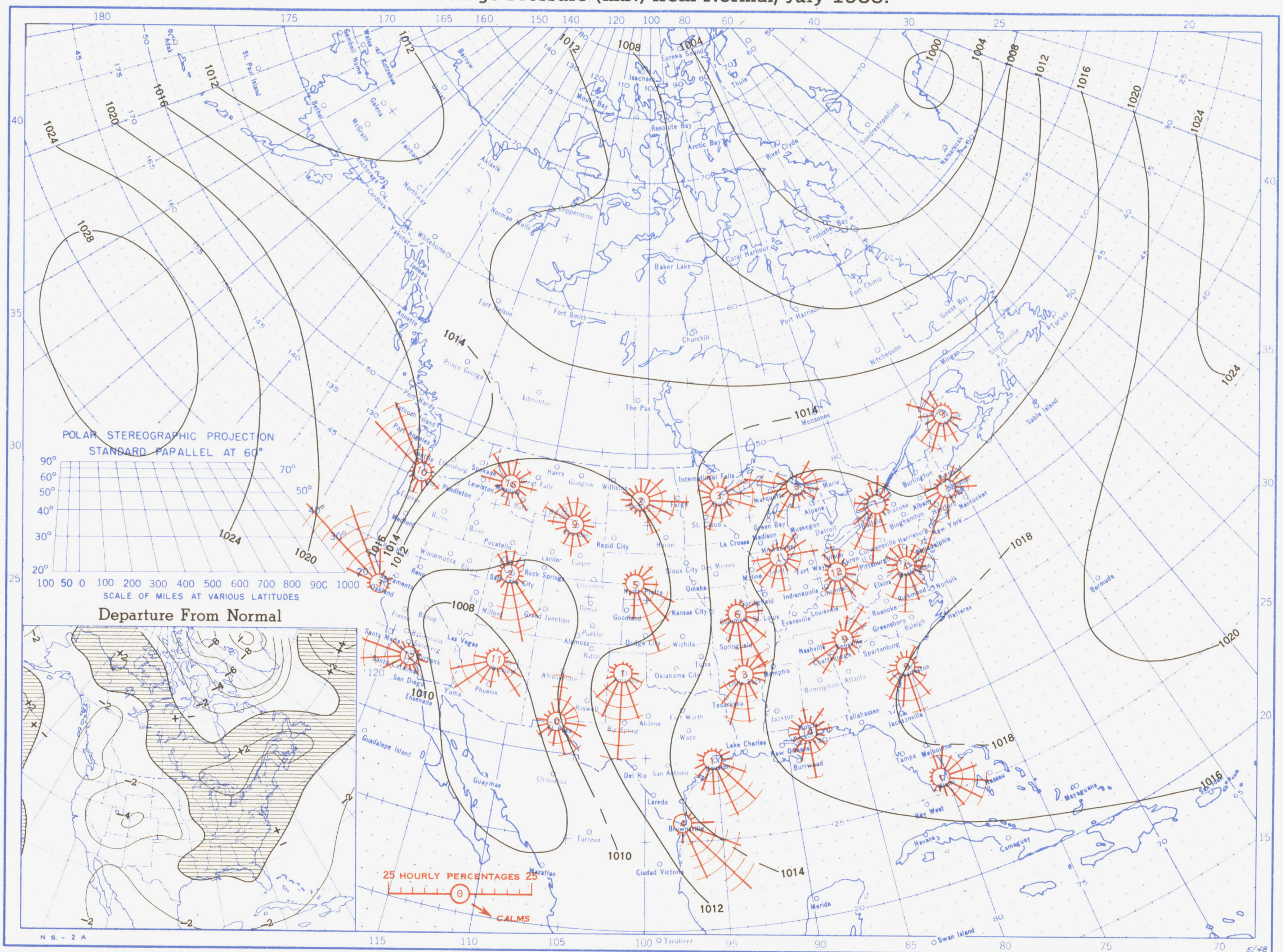
Circle indicates position of center at 7:30 a. m. E. S. T. Figure above circle indicates date, figure below, pressure to nearest millibar. Dots indicate intervening 6-hourly positions. Squares indicate position of stationary center for period shown. Dashed line in track indicates reformation at new position. Only those centers which could be identified for 24 hours or more are included.

Chart X. Tracks of Centers of Cyclones at Sea Level, July 1955.



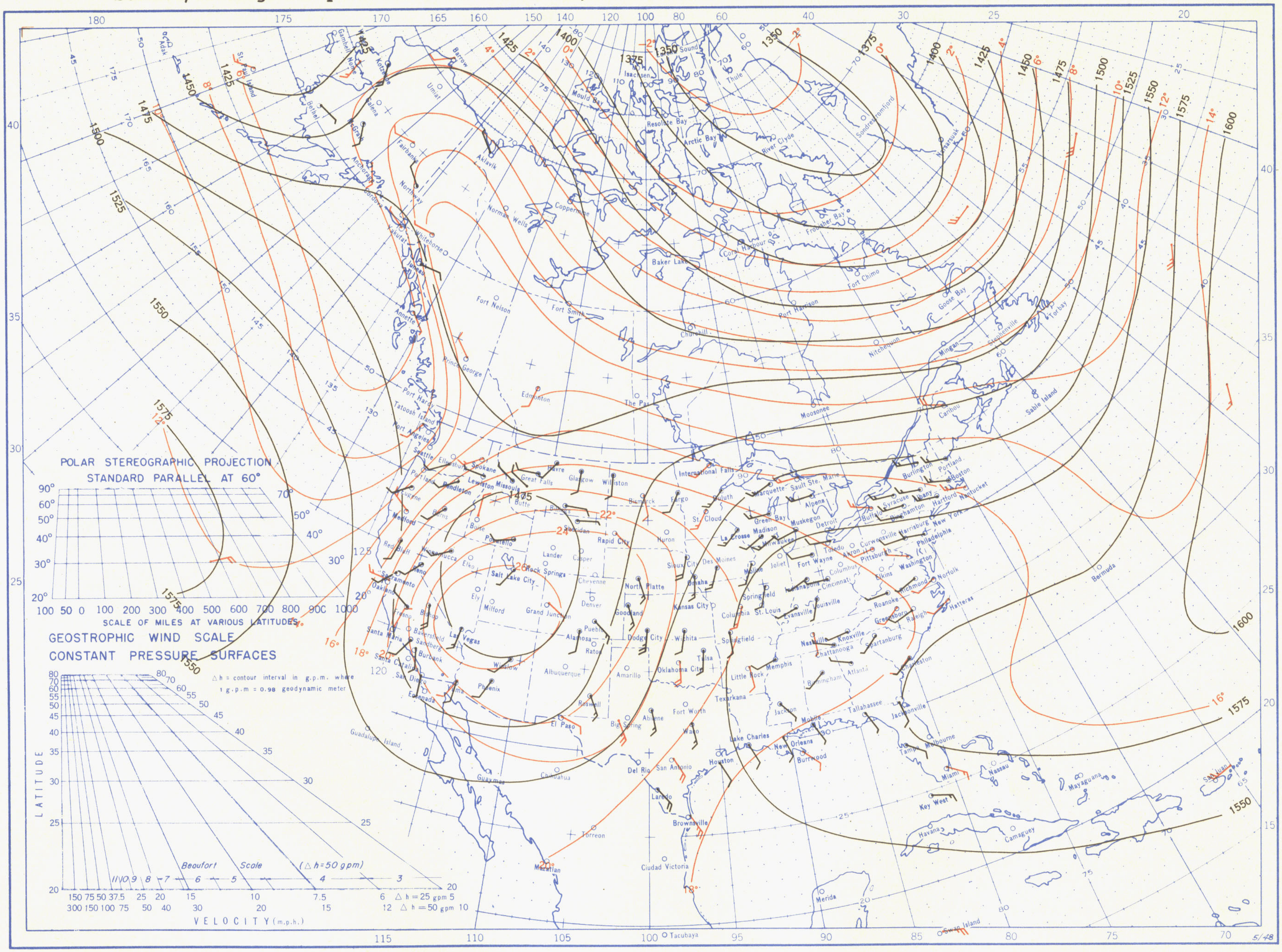
Circle indicates position of center at 7:30 a. m. E. S. T. See Chart IX for explanation of symbols.

Chart XI. Average Sea Level Pressure (mb.) and Surface Windroses, July 1955. Inset: Departure of Average Pressure (mb.) from Normal, July 1955.



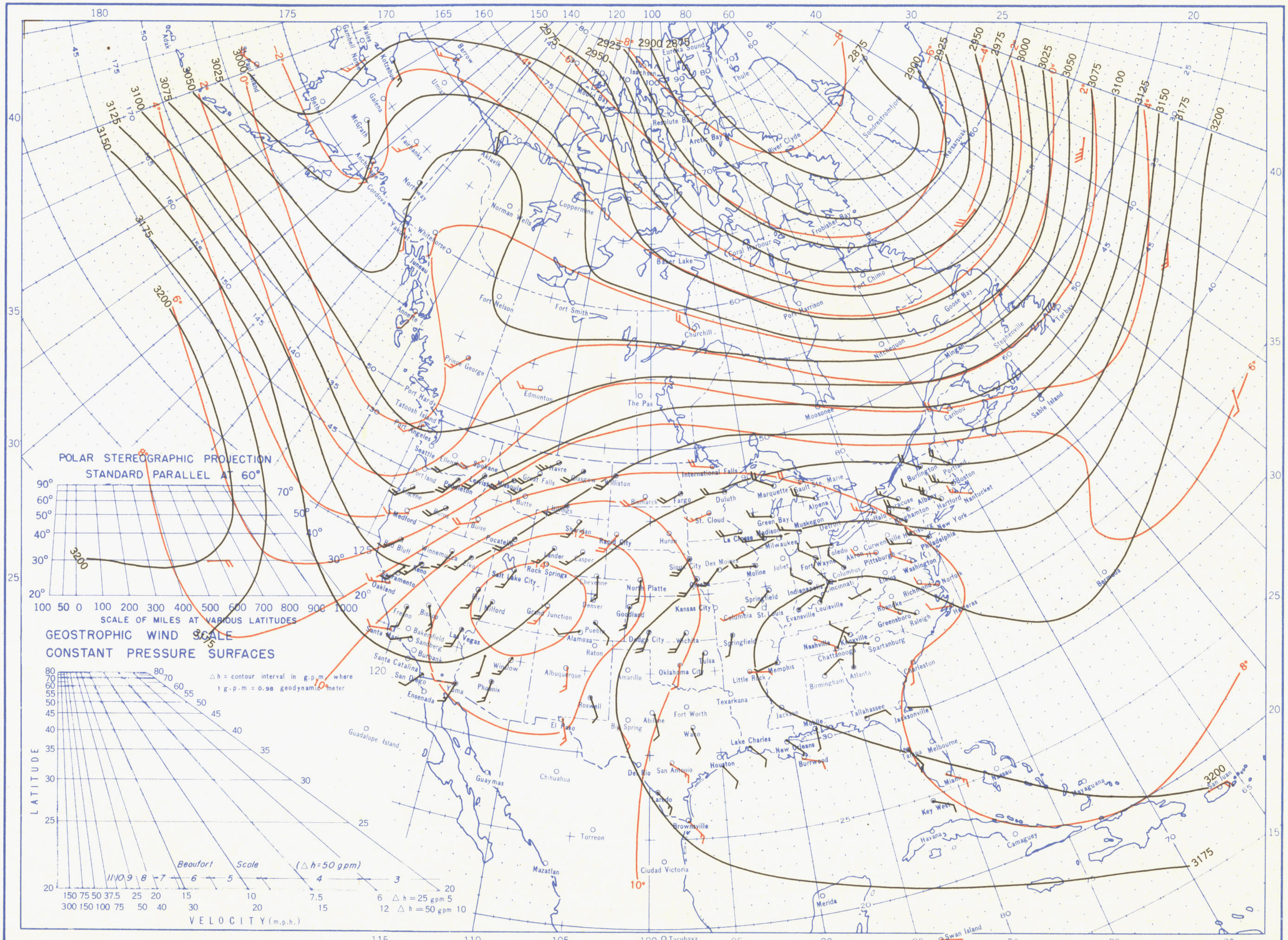
Average sea level pressures are obtained from the averages of the 7:30 a. m. and 7:30 p. m. E. S. T. readings. Windroses show percentage of time wind blew from 16 compass points or was calm during the month. Pressure normals are computed for stations having at least 10 years of record and for 10° intersections in a diamond grid based on readings from the Historical Weather Maps (1899-1939) for the 20 years of most complete data coverage prior to 1940.

Chart XII. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 850-mb. Pressure Surface, Average Temperature in °C. at 850 mb., and Resultant Winds at 1500 Meters (m.s.l.), July 1955.



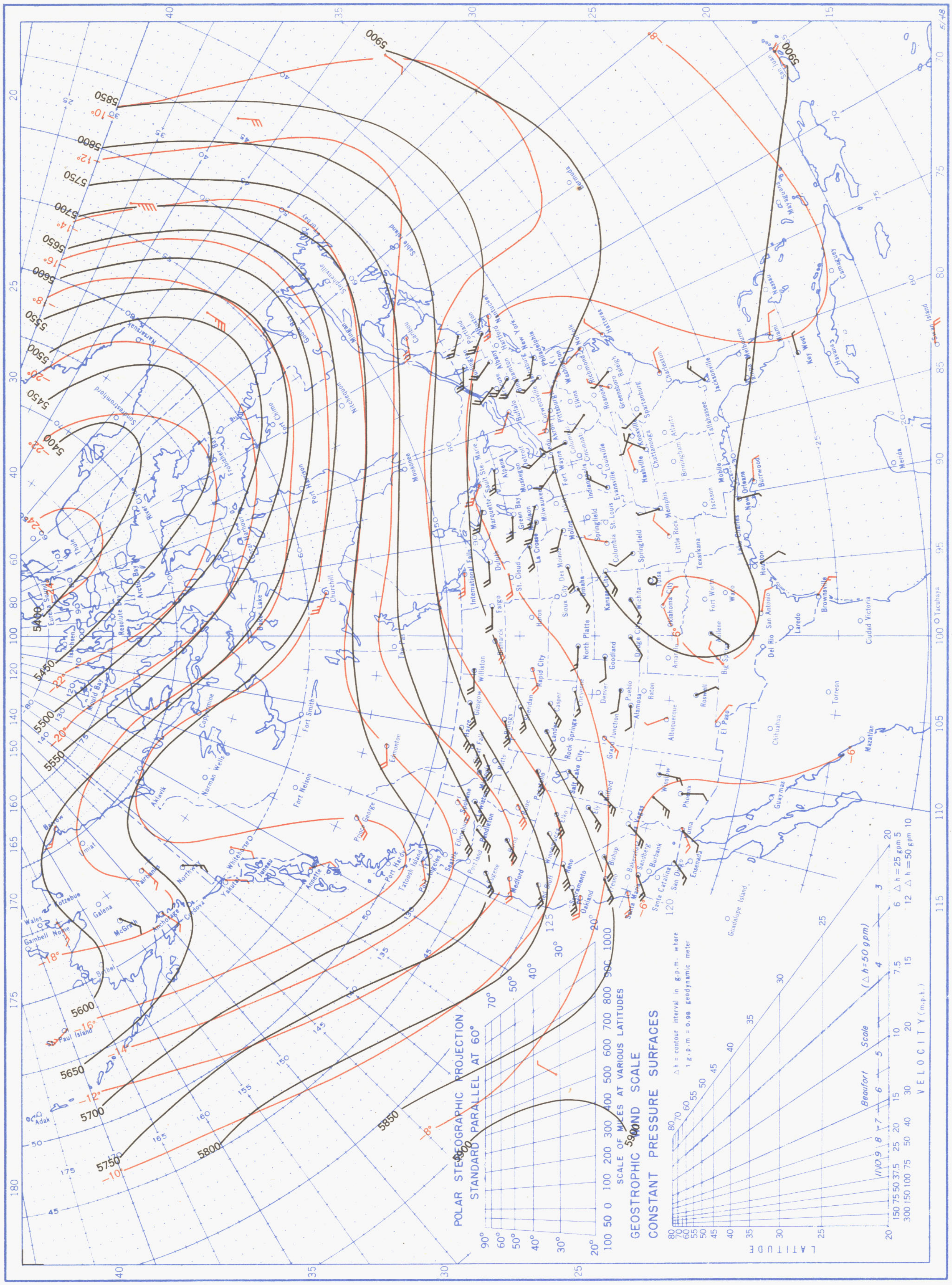
Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.

Chart XIII. Average Dynamic Height in Geopotential Meters (1 g.p.m.. = 0.98 dynamic meters) of the 700-mb. Pressure Surface, Average Temperature in °C. at 700 mb., and Resultant Winds at 3000 Meters (m.s.l.), July 1955.



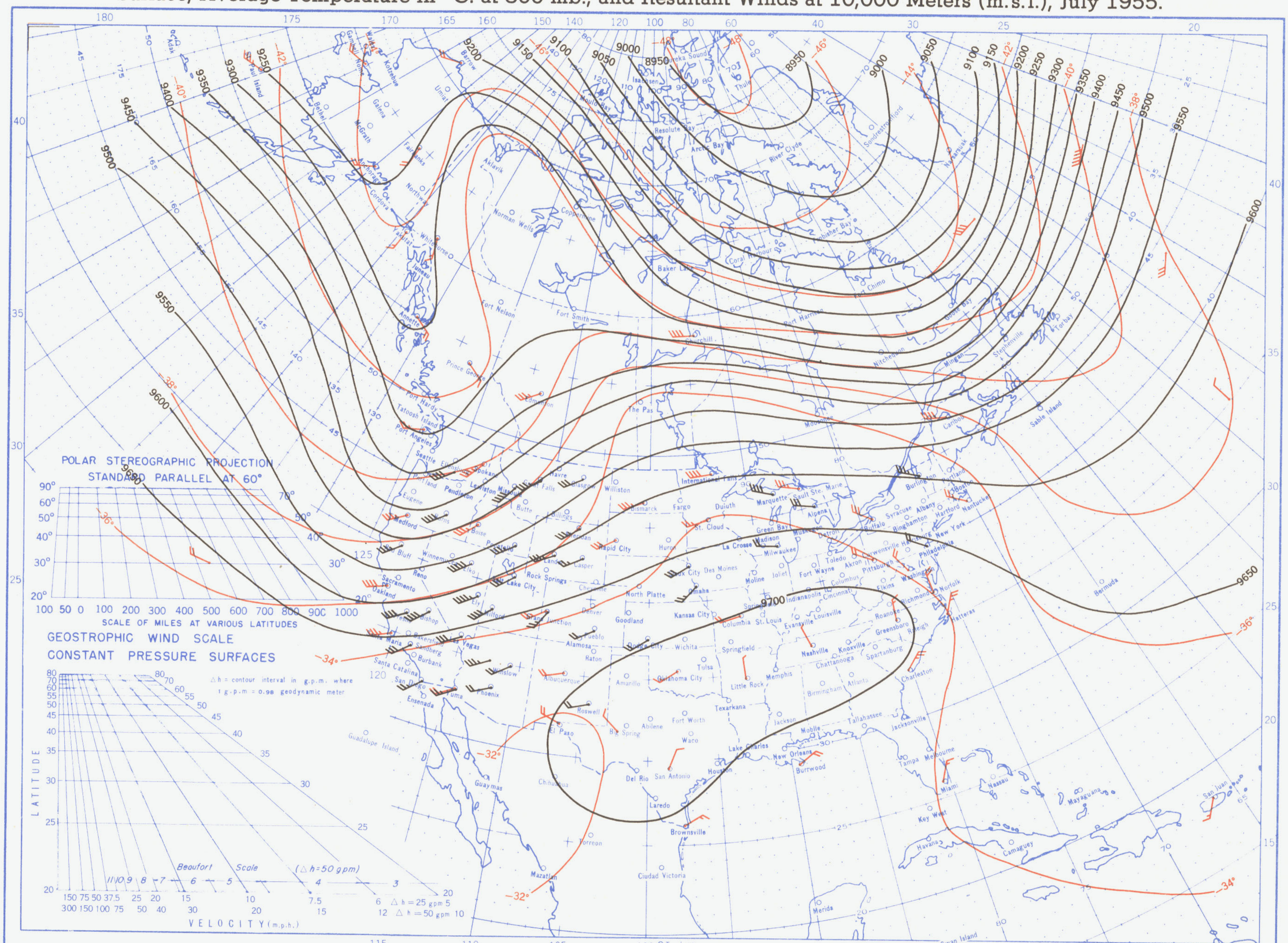
Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.

Chart XIV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 500-mb. Pressure Surface, Average Temperature in °C. at 500 mb., and Resultant Winds at 5000 Meters (m.s.l.), July 1955.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.

Chart XV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 300-mb. Pressure Surface, Average Temperature in °C. at 300 mb., and Resultant Winds at 10,000 Meters (m.s.l.), July 1955.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.